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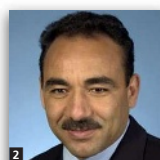
Incorporating an economic measure in sustainability assessment

1 **Doug Forbes** MEng, PhD
Senior Consultant, Whole Life Consultants Ltd, Dundee, UK

2 **Mohamed El-Haram** PhD
Senior Research Fellow, University of Dundee, UK

3 **Simon Smith** PhD, CEng, MICE
Senior Lecturer, University of Edinburgh, UK

4 **Malcolm Horner** PhD, CEng, FICE, FRSE
Emeritus Professor of Engineering Management,
University of Dundee, UK



Breeam, The Building Research Establishment's environmental assessment method, is a suite of tools designed to measure the environmental performance of buildings. Although originally designed for a UK context, it has been adapted for and influenced a range of building rating systems worldwide. The domestic scheme, Ecohomes, was originally designed as an environmental assessment method. This paper analyses the spread of indicators used and seeks to address any gaps. Analysis of the indicators found that there is a very reasonable coverage of environmental indicators in the scheme, and this is complemented by a reasonable coverage of social indicators. However, there is a complete avoidance of the economic dimension. A means of incorporating an economic dimension should be considered to make the scheme a three-dimensional sustainability assessment method. The approach develops a sustainability ratio based on the existing scheme score to measure the environmental and social dimensions, while capital construction cost defines the economic dimension. It is possible that with further industrial consultation the approach could be transferred and applied to other building rating methods.

1. Introduction

Sustainability takes into account social, economic and environmental issues. The built environment has a significant impact on all three, although the exact impact is a matter of current debate. For example, from an environmental perspective, buildings in the UK account for around a half of total carbon dioxide emissions and a third of landfill waste (BERR, 2008). Socially, poor physical conditions have been found to be detrimental to communities (Egan, 2004). It is therefore not surprising that buildings have become a focus in attempts to meet sustainability targets. This is clearly visible in the UK: the government is using the housing sector as a principal means of policy delivery – particularly in relation to carbon dioxide emissions. The target in England and Wales is for net zero carbon homes by 2016 (DCLG, 2007). One of the tools used to measure delivery of this is the Code for Sustainable Homes (DCLG, 2008). The code is, to a large extent, based on the Building Research Establishment (BRE)'s environmental assessment method (Breeam) for homes – Ecohomes. The scheme was first developed in 2000 and supplemented a suite of

assessment methods that previously existed for non-domestic buildings (Rao *et al.*, 2000). Breeam was the first simplified environmental certification scheme of its kind when it was developed in 1990 (Howard, 2005). Its development since has influenced the development of other assessment methods throughout the world (Cole, 2006). The scheme underwent revisions in 2003, 2005 and 2006. It was the main environmental assessment method for housing in the UK until the Code for Sustainable Homes was introduced in May 2008. Since that time, there has been a mandatory requirement for all new homes in England to be assessed under the code. In Scotland, the standard remains Ecohomes 2006.

2. Breeam and Ecohomes

The suite of Breeam non-domestic schemes and Ecohomes all function in similar ways. Eight headline categories are measured

- (a) energy
- (b) transport

- (c) pollution
- (d) materials
- (e) water
- (f) land use and ecology
- (g) health and wellbeing
- (h) management.

Under each of the issues a set of points is awarded. These are then calculated as a percentage of the total available for each issue. The score achieved from the credits for each issue is then multiplied by the weight. This provides a weighted score, which is the overall assessment score. This score is then translated into building ratings of 'pass' (>36%), 'good' (>48%), 'very good' (>58%) and 'excellent' (>70%).

The points awarded in each category are based on indicators. The indicators are specific to the type of building being assessed. For instance, the indicators for transport differ between domestic and non-domestic buildings. In the homes version, the indicators are tailored to the housing sector. For instance, the water category is measured in part by the annual potable water use and energy in part by the dwelling's carbon dioxide emission rate.

An important issue associated with the scheme has been its incremental and evolutionary development. Originating as an environmental assessment method, it is evidently very strong at measuring the environmental dimension of sustainability. However, it is clear that there are a number of indicators designed to measure and award points for social considerations. It also appears that there is an almost complete dearth of indicators to attempt to measure the economic dimension. The question that remains is: how comprehensively does the scheme address each of the three dimensions, if at all?

3. To what extent does Ecohomes address all three dimensions of sustainability?

The response to this question opens up a larger problem: what should be measured in a sustainability assessment? Research undertaken by the SUE-MOT project has investigated metrics, models and toolkits for whole-life urban sustainability (SUE-MOT, 2007). One of the work packages in this research developed a full cost accounting package for the sustainability of urban developments, called the urban developments sustainability assessment model (UD-SAM) (Xing *et al.*, 2007). The researchers identified a set of key impacts for the sustainability of urban developments. These impacts were compiled from an extensive review of the literature, which identified in excess of 600 sets of sustainable development indicators. These were then considered and validated by stakeholders through a workshop and questionnaire survey. This defined 24 significant impacts of sustainability (Xing *et al.*, 2007). Further work has developed and simplified these

into 18 impacts (El-Haram *et al.*, 2008). These impacts are grouped under the three headline dimensions of social, economic and environmental issues.

3.1 An approach to consider the coverage of indicators

The indicators in the homes version were cross-mapped with the UD-SAM impacts that they address. This investigated how comprehensively the scheme measures the 18 impacts used in UD-SAM, and consequently, therefore addresses all three dimensions of sustainability. This mapping exercise is presented in Figure 1.

The ability for Ecohomes indicators to measure social, environmental and economic issues was defined on two levels. The first of these considered whether the primary aim of the indicator was to address the impact. The second level considered whether the impact was addressed as a by-product of the metric used in the indicator. This mapping exercise identified that all of the environmental and most of the social impacts were measured by at least one of the 33 indicators in the scheme. The only social impact not measured was the impact on heritage. There was no indicator representing any impacts in the economic dimension.

A subjective assessment was then made of the extent to which each of the impacts is measured using the homes version. This considered each of the UD-SAM impacts in turn and the ability of the scheme to measure each dimension of sustainability. Three degrees of coverage were defined for the scheme – low, medium and high. The associated definitions are outlined in Table 1. The associated level for each of the 18 UD-SAM impacts is presented in Table 2.

3.2 Coverage of indicators in Ecohomes

This analysis demonstrates that the scheme has a reasonably comprehensive set of indicators to measure the environmental impacts of sustainability. This is unsurprising, given the historic background to the scheme. The only impact of concern in the ability of the scheme to measure environmental issues was pollution to land. However, this was compensated by the reasonable coverage of this impact by secondary aims of indicators, and the comprehensive coverage of other environmental impacts. In contrast to relatively full coverage of environmental impacts, there is a complete failing of the scheme to take account of economic impacts. It is noted that a whole-life cost exercise is included in the renewable energy feasibility study for awarding pollution 4 credits (renewable and low energy emission energy source). However, it is not the primary or secondary aim of this indicator. The scope is limited to renewable energy sources at feasibility stage and has therefore not been considered as a by-product of the indicator.

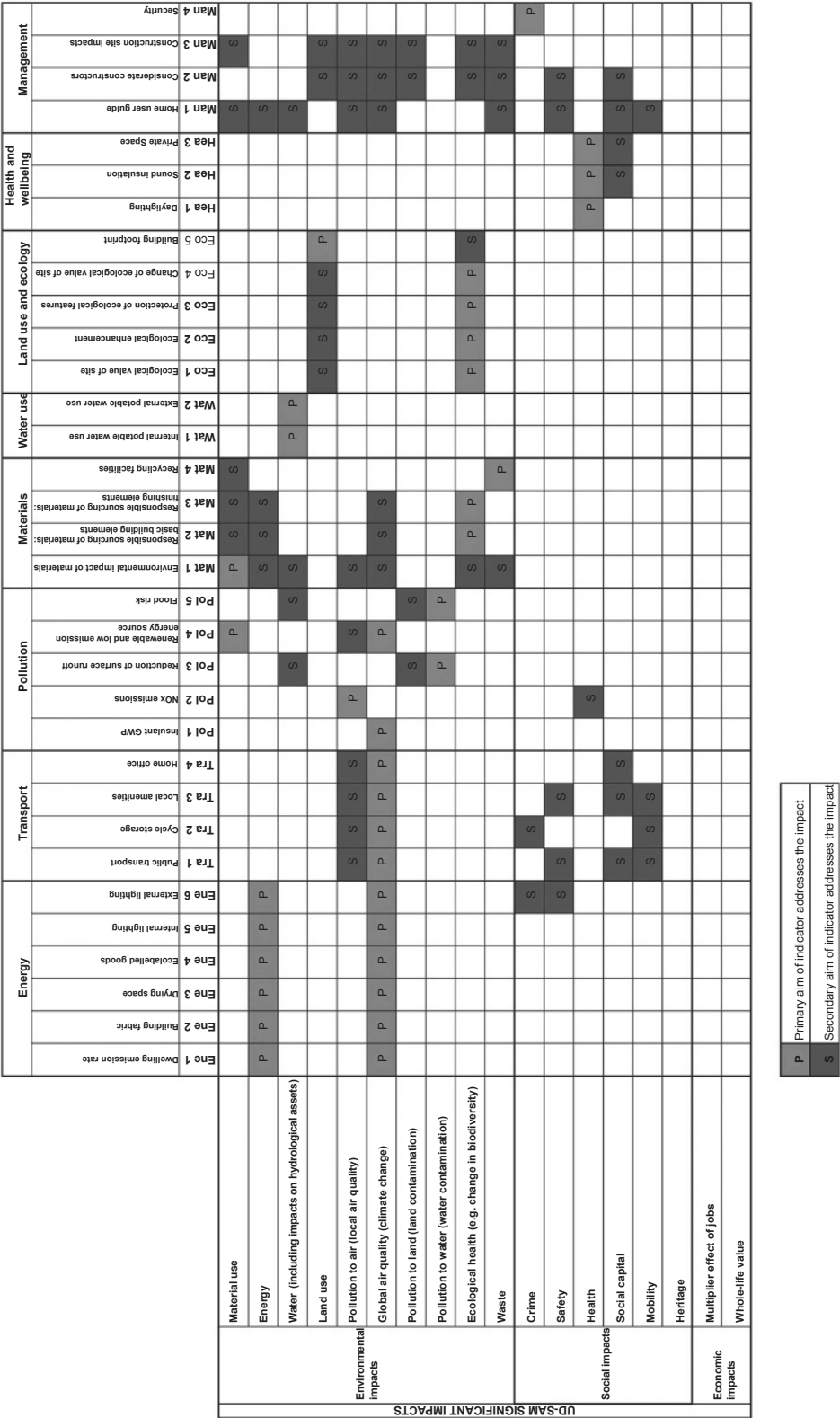


Figure 1. Comparison of Ecohomes indicators with urban sustainability impacts

Coverage	Definition
Low	Not covered at all by Ecohomes
Medium	Covered in part by Ecohomes
High	Comprehensively covered by Ecohomes

Table 1. Definitions used to define the range of indicator coverage

This does not therefore address the economic impacts in the UD-SAM.

The economic and environmental impacts are the two extremes; social issues, being partially covered, lie between the two. All of the social issues were covered, at least in part, by scheme indicators, except heritage. Health impacts were considered to be comprehensively covered. This is due to the inclusion of the health and wellbeing category in the scheme. The primary aims of all three indicators in this category address this aim. The crime impact was considered to be addressed between ‘comprehensive’ and ‘in part’ levels. This was due to a mixture of primary and secondary indicators that do not address these issues in sufficient detail to merit a ‘high’ rating of coverage.

Ecohomes indicators cover safety, social capital and mobility issues in part. However, the very nature of these three impacts creates difficulties in their measurement (Moobela *et al.*, 2007; Pearce, 2006). They have been addressed in the scheme through

a range of secondary indicators and thus it cannot be considered that a comprehensive approach has been developed.

3.3 Does Ecohomes address all three dimensions?

This analysis is important because it effectively demonstrates the extent to which the scheme addresses sustainability issues in three dimensions. While it is widely considered that the scheme is an environmental assessment method, recent revisions have included an increase in social indicators. Introducing these indicators has resulted in an approach that considers, to a large extent, all the social impacts associated with sustainability. However, most of the social impacts are addressed by secondary aims of the indicators. Thus, it would seem that, apart from crime and health, this inclusion has been an ‘add-on’ rather than a deliberate attempt to incorporate the social dimension. However, the social dimension is among the least understood in sustainability. Therefore it is considered that there is a reasonable coverage of these two issues in the scheme.

This ability to measure two dimensions simultaneously means that the assumption that the scheme is purely an environmental assessment method needs to be dismissed. The scheme must be applied in the context and with the understanding that a large number of social impacts are also considered, albeit by way of the secondary aim of certain indicators. So, if the scheme is to measure sustainability fully, it is vital that economic issues must also be included.

Dimension of sustainability	Impact	Probability of failure to be addressed Ecohomes
Environmental	Material use	High
	Energy	High
	Water (including impacts on hydrological assets)	High
	Land use	High
	Pollution to air (local air quality)	High
	Global air quality (climate change)	High
	Pollution to land (land contamination)	High–medium
	Pollution to water (water contamination)	High
	Ecological health (e.g. change in biodiversity)	High
	Waste	High
	Crime	High–medium
	Safety	Medium
Social	Health	High
	Social capital	Medium
	Mobility	Medium
	Heritage	Low
Economic	Multiplier effect of jobs	Low
	Whole-life value	Low

Table 2. Range of coverage of urban sustainability issues in Ecohomes

4. The coverage of Ecohomes indicators

As noted, while the scheme measures environmental and social dimensions to a reasonable extent, it entirely fails to take account of the economic dimension in a meaningful manner. This is unacceptable if the scheme is truly to measure sustainability in three dimensions. The remainder of this section discusses an approach proposed to incorporate economic considerations.

4.1 The cost of sustainable housing

The additional cost of 'sustainable' construction is, like many issues in sustainability, debatable. In the housing field, two comprehensive studies have investigated the cost of achieving different levels in the code for sustainable homes and Ecohomes. However, because of the multitude of possible combinations and the constraints placed on the assessment by site and design conditions, it is difficult to define consistent base cases.

The Ecohomes study, performed by BRE and Cyril Sweett (2005a; 2005b), was based on Ecohomes 2003 and considered a house compliant with building regulations. The three base cases in the study considered a poor, typical and good site, with respective scores of 22.1, 27.6 and 29.7%. It was estimated that cost increases of 0.1–6.9% were necessary to achieve an 'excellent' rating. Townshend (2007) found that a developer in Newcastle, UK incurred additional costs of 7.5% to achieve an Ecohomes excellent rating.

An updated study considering the Code for Sustainable Homes (HCEP, 2007) estimated that additional construction costs in the region of 25–37% would be required to achieve a level 6 rating. This large increase in construction costs is reflected by The Stewart Milne Group, one of the first developers to build to level 6 of the code. The company estimate, at prototype stage of a three/four-bedroom detached property, level 5 would

Percentile	Construction cost: £m ²	
	Houses	Flats
10	216	314
20	272	432
30	325	536
40	372	633
50	412	706
60	460	820
70	533	906
80	593	1065
90	727	1286
100	1897	2657

Table 3. Construction cost per unit area for houses and flats (BCIS, 2008)

add £40 000 to construction costs; level 6 would increase construction costs by £60 000–£70 000 (Peedle, 2007).

Notwithstanding increased capital costs, a small number of researchers have investigated the effect of increased sustainability on whole-life costs. Zhou and Lowe (2003) concluded that considering costs over a lifecycle is the key to incorporating the economic dimension of sustainability. Smith *et al.* (1997) noted that despite a 1.1% increase in capital costs, savings of 10.3% (using a 3.9% discount rate) and 5.2% (using an 8.0% discount rate) over a 60-year lifecycle were achievable in more sustainable housing. Similar savings over the lifecycle of a sustainable home were found by the Environment Agency (Horton, 2005). Horton's research demonstrated that over a 25-year lifecycle, savings of £11 834–£16 679 per dwelling were possible using a 3.5% discount rate from an increased spend of £7100–£22 100. These reports on the costs of 'sustainable' housing therefore demonstrate that there is a wide range of differing costs associated with how much extra capital is required to achieve high sustainability levels. There is also a distinct lack of evidence on any whole-life cost benefits arising from increased sustainability considerations.

4.2 Incorporating the economic dimension

The UD-SAM proposed the multiplier effect of jobs and whole-life value as economic impacts. The inclusion of an indicator that can attempt to measure these in the scheme is now considered.

The studies cited earlier highlight the discord that exists in the published costs of sustainable housing and the effect on whole-life costs. In principle, incorporation of the economic dimension

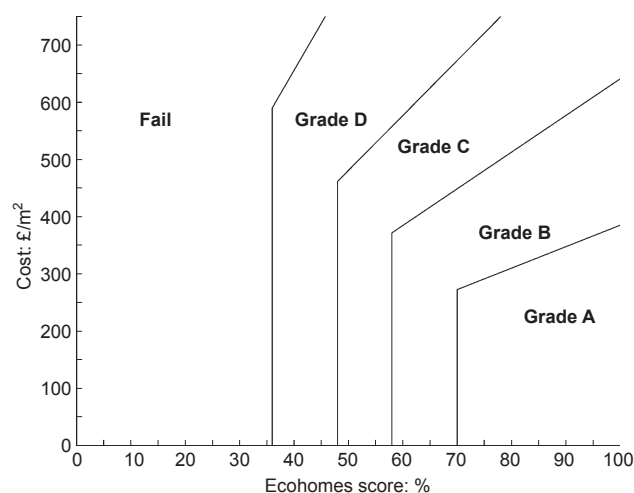


Figure 2. Thresholds to incorporate an economic dimension with Ecohomes score for housing

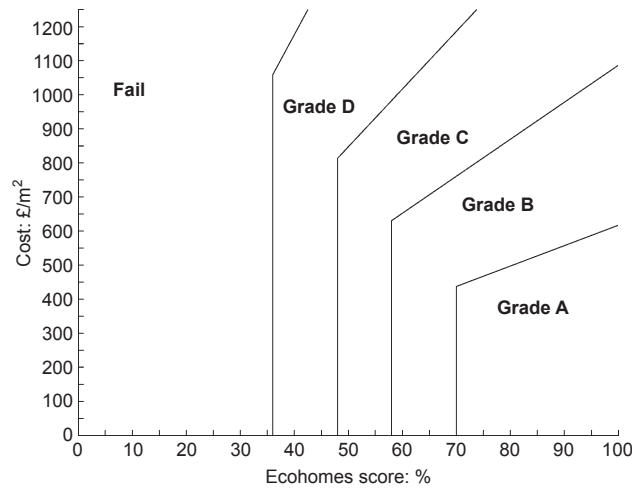


Figure 3. Thresholds to incorporate an economic dimension with Ecohomes score for flats

of sustainability in the scheme would take account of whole-life costs. However, this research developed an approach that uses the capital construction cost of dwellings because sufficient reliable data for whole-life costs are unavailable. Quarterly costs for construction of housing are published for the UK by the Building Cost Information Service (BCIS). Table 3 shows the distribution of construction costs for flats and houses (BCIS, 2008). The prices given are for a UK mean location and are based on costs for the fourth quarter of 2007. They are given per square metre of gross internal floor area, excluding external works and contingencies. Preliminaries should be distributed in proportion to cost.

The approach developed ensures that construction costs are minimised while maximising social and environmental benefits. The social and environmental benefits are measured by the Ecohomes score, and the effectiveness of the existing scheme

method has been demonstrated. The costs are measured using the construction cost per square metre indexed for temporal and location differences. A distinction between flats and houses was also used; this is a distinction that is inherent in Ecohomes. Five grades of award were defined for this research (grades A–D and fail), reflecting the five grades in the current scheme version. The relationship between cost and Ecohomes score is given in Figure 2 and Figure 3 for houses and flats respectively.

Boundaries in Figures 2 and 3 were defined by incorporating two measures. The thresholds on the horizontal axis are defined by the existing scheme thresholds. The scheme score thresholds are defined by BRE to award developments that go beyond the regulatory minimum. An ‘excellent’ rated development is therefore at the higher percentiles of environmental and social performance. Using this basis, the costs were split into five equal segments to mirror the five Ecohomes ratings. The boundaries for this were taken as the 20, 40, 60 and 80 percentiles. These were selected to mimic the five existing bands of Ecohomes (fail, pass, good, very good and excellent). In theory, these bands should be sized to reflect the distribution of the number of properties in each Ecohomes rating. For instance, if 10% of new homes are ‘excellent’ then this would be within the top 10% of cost. However, as the distribution of number of dwellings in each rating is unavailable, a uniform distribution was assumed. The points of inflection were established by the point where the 20 percentile of costs coincided with the ‘excellent’ threshold of 70%, the 40 percentile coincided with the ‘very good’ threshold of 58%, and similarly for the remaining limits. Defining these points in this way ensures that buildings that achieve an ‘excellent’ performance environmentally and socially are also delivering it within the top 20% of unit cost. However, to allow for an increased cost as the scheme score exceeds the social and environmental thresholds, the grade boundaries are sloped. The slope of these lines is defined by the ratio of Ecohomes score to cost at the point of inflection. For instance, for

Grade	Economic score threshold		Ecohomes threshold (social and environmental score): %
	Housing ratio	Flats ratio	
[1]	[2]	[3]	[4]
A	>0.257	>0.162	≥70
B	>0.156	>0.092	≥58
C	>0.104	>0.059	≥48
D	>0.061	>0.034	≥36
Fail	≤0.061	≤0.034	<36

Table 4. Gradings defined for three dimensions of sustainability measurement using Ecohomes

housing to be 'grade A' it must be in the top 20 percentile of cost ($<£272/\text{m}^2$) at an Ecohomes score of 70%. This ratio is 0.257. Therefore, if the same project were to obtain a score of 90% it must maintain costs below $£350/\text{m}^2$ ($90/0.257$). This grading process encourages developments to aim for the bottom right-hand corner of the chart – maximum social and environmental benefits for minimum cost. The sloped boundaries account for increased costs associated with higher levels of sustainability.

A graphical display is not the most appropriate method for this approach to be used in practice during an assessment. Furthermore, it is not consistent with the format of the Ecohomes guidance, which uses numerical values as thresholds. A three-dimensional scheme score ratio of unit cost to Ecohomes score can be calculated from

$$1. \quad \text{Ratio} = \frac{\text{Ecohomes score (\%)}}{\text{Cost per unit area (£/m}^2\text{)}}$$

This ratio should be maximised to achieve the greatest measure of sustainability in three dimensions, therefore achieving the highest possible social and environmental benefits for the minimum unit cost. The thresholds are defined for each of the grades in Table 4 using the points defined in Figures 2 and 3. To obtain each grade, a development must have an economic ratio higher than that given in columns [2] and [3] for houses and flats respectively and an Ecohomes rating higher than that given in column [4].

This approach allows the economic dimension to be considered in conjunction with the social and economic issues measured by the scheme. It rewards assessments that maximise the Ecohomes score while minimising cost per unit area. Regional and temporal differences in cost are taken into account by indexing the costs to a UK mean location and fourth quarter 2007 prices. This creates an indicator to measure the economic dimension of sustainability. Comparison with UD-SAM highlighted two economic issues in sustainability assessments of urban developments – whole-life value and the economic multiplier effect of jobs. This indicator attempts to measure the first of these and creates a step forward in forming a three-dimensional measure despite some notable limitations. It is acknowledged that this approach is limited by only including the capital cost. However, while this may seem contradictory to the measure of whole-life value, it has been shown in a limited number of studies that increasing environmental and social sustainability reduces whole-life costs. To an extent, the environmental and social metrics measured by the scheme take account of the impact of the dwelling over the whole life. However, further investigation is needed into the effect of an increased Ecohomes score on whole-life costs. Further research

is also required to determine if whole-life costs or capital costs are more appropriate to use as a metric for economic impacts.

5. Conclusions

Ecohomes and the rest of the Breeam suite are among the most commonly used sustainability assessment methods for buildings. One of the challenges associated with their use is the extent to which they actually assess sustainability; indeed what is actually meant by sustainability in the first place? If it is assumed that sustainability incorporates the environmental, social and economic dimensions, then the scheme does not measure all three. It does cover social and environmental issues, and this means that it can be effectively used to measure social and environmental sustainability. Despite its origins as an environmental assessment method, the scheme cannot be used in its current form to measure solely environmental sustainability. The social indicators included are too numerous to permit this.

The approach used to incorporate an economic dimension has continued with the assumption that the scheme as it currently stands serves as an effective measure of social and environmental sustainability. The proposed approach then used this measure and combined it with the current distribution of domestic UK construction costs. This resulted in a three-dimensional sustainability ratio that can be used to grade a housing development.

The approach is limited as it used data from only one source (BCIS). The method uses the current distribution of costs for housing per unit area and does not take any account of increased costs incurred by increasing sustainability or whole-life costs. There are significant issues associated with reliable data on the whole-life costs of sustainable buildings. Further consultation and research is required to define the threshold points for each grade. It should also be noted that this approach does not include the second significant economic impact, the multiplier effect of jobs. Further opportunities to include the multiplier effect of housing should be considered in future research.

The proposed approach is considered to be a significant step forward in the ability of the scheme to measure the three dimensions of sustainability. However, it should be noted that the principles outlined in this paper should not be solely limited to the Ecohomes assessment method. It has potential for adaptation to other types of Breeam-assessed buildings and other building rating systems based on Breeam. There is also potential for incorporation into other 'simplified' assessment methods that regularly fail to take account of the economic dimension. This can then facilitate the assessment of sustainability of wider communities in all three dimensions by using these tools to assess buildings.

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